

ZANZIBAR GOVERNMENT

Mycologist's Annual Report
1922 -

Mycologist's Annual Report

1922.

My copy of General Report

1922

CONTENTS

Page

Introduction.	1
Part 1. Report on clove diseases.	2
Part 2. Report on various diseases.	34
Part 3. Report on Experimental Garden, Weti.	38
Part 4. Bibliography.	50
Part 5. Suggested circular.	53
Part 6. Index.	
Appendix on oil contents of trunks.	56

Introduction

Part 1.	Report on clove diseases.	1
Part 2.	Report on various diseases.	34
Part 3.	Report on Experimental Garden, West.	50
Part 4.	Bibliography.	60
Part 5.	Suggested curriculum.	63
Part 6.	Index.	70
	Appendix on all contents of books.	

MYCOLOGIST'S REPORT

Sir,

I have the honour to submit the following report, on the work done by me, since my arrival in the Zanzibar Protectorate, on March 28th 1921.

In accordance with the instructions received on my appointment as mycologist, my chief duty has been to investigate the condition of the clove trees.

I have in addition examined diseased plants of cocoanut, cassava, cucumber etc, and have started an experiment garden at Weti.

I wish to take this opportunity of recording my thanks to the officials of both islands, who have helped me in every way in their power. I am specially indebted to Mr. F.C. McClellan C.B.E. Director of Agriculture who has most generally helped me with his special knowledge, as well as with all the resources of his department.

I wish also to record my indebtedness to Mr. Theodore Burt of the Friends' Industrial Mission at Banani; his practical knowledge of the clove extends over 26 years and his experience has been most valuable to me.

I have the honour to be,

Sir,

Your obedient servant.

E. J. Welsford.

MYCOLOGIST.

Weti. December 31st 1922.

MYCOLOGIST REPORT

Sir,

I have the honor to submit the following report on the work done by me since my arrival in the Cameroons Protectorate on March 28th 1921.

In accordance with the instructions received on my appointment as mycologist, my chief duty has been to investigate the condition of the clove trees.

I have in addition examined diseased plants of cocconut, cassava, cucumber etc, and have started an experiment garden at Wele.

I wish to take this opportunity of recording my thanks to the officials of both islands who have helped me in every way in their power. I am especially indebted to Mr. E.C. McCallister O.E.N. Director of Agriculture who has most generously helped me with his special knowledge as well as with all the resources of his department.

I wish also to record my indebtedness to Mr. Theodore Hart of the Friends Industrial Mission at Bonani; his practical knowledge of the clove extends over 25 years and his experience has been most valuable to me.

I have the honor to be,

Sir,

Your obedient servant.

MYCOLOGIST.

Wele, December 31st 1922.

A
PART 1 CLOVE DISEASES.
-----A-----

The clove is grown in both Zanzibar and Pemba islands, the number of trees has been approximately estimated in 1922 as $1\frac{1}{4}$ million in Zanzibar and $2\frac{1}{4}$ million* in Pemba. Many trees are dying and many other are in an unhealthy condition in both islands but the reports from Pemba have been the most alarming. For this reason I was sent to Pemba in April 1921 and took up my residence at Weti. This station proved satisfactory for most of the work, the clove shambas are very accessible and there are plenty of unhealthy trees on the immediate neighbourhood.

The weekly Government steamer and the departmental motor launch have made visits to the shambas of both islands possible and have enabled me to compare the trees growing in different places.

A preliminary examination of the clove trees in different parts of the Protectorate suggested that the existing state of things was probably due to a complication of factors, rather than to one specific disease; further work has confirmed this opinion. It seemed therefore advisable to obtain some knowledge of the general history of the clove as well as of the local history of a few shambas with a view to discriminating between factors due to environment rather than to specific diseases.

History.

The clove tree Eugenia caryophyllata ^{um} Theenb, belongs to the natural order Myrtaceae and is believed to be indigenous in the Molucca islands. Sea air is said to be necessary for its successful cultivation and it only flourishes in islands between the latitudes of 20 N. and 25 S. of the equator.

* actual figures are Zanzibar 1,251,409 & Pemba 204,804 including 4610 year old trees. All references to literature.

PART I. CLOVE DISEASES.

The clove is grown in both Zanzibar and Pemba islands, the number of trees has been approximately estimated in 1932 as follows in Zanzibar and Pemba. Many trees are dying and many others are in an unhealthy condition in both islands but the reports from Pemba have been the most alarming. For this reason I was sent to Pemba in April 1931 and took up my residence at West. This station proved satisfactory for most of the work, the clove chambers are very accessible and there are plenty of unhealthy trees on the immediate neighbourhood. The weekly Government steamer and the departmental motor launch have made visits to the chambers of both islands possible and have enabled me to compare the trees growing in different places.

A preliminary examination of the clove trees in different parts of the Protectorate suggested that the existing state of things was probably due to a combination of factors rather than to one specific disease; further work has confirmed this opinion. It seemed therefore advisable to obtain some knowledge of the general history of the clove as well as of the local history of a few chambers with a view to discriminating between factors due to environment rather than to specific diseases.

The clove tree *Wassia carvophylla* Thunb. belongs to the natural order Myrtaceae and is believed to be indigenous in the Molucca Islands. See also is said to be necessary for its successful cultivation and it only flourishes in islands between the latitudes of 30° N and 35° S of the equator.

All references to literature

(18) *

The earliest records[^] of clove trading are found in various Chinese manuscripts of B.C. 266 and it appears from the work of Cosmas Indicopl^eustes of A.D. 547 and Mar^c Polo A.D. 1260 that this nation was chiefly responsible for the early trade with both India and Europe.

After a time the Portuguese seized the Moluccas and took the European clove trade out of the hands of the Chinese, but they, in their turn, were ousted in the 17th century, by the Dutch, who tried to establish a monopoly of the trade. The Dutch attempted to limit clove cultivation to Amboyna, but were only tempor^aily successful, for in the eighteenth century by the efforts of advent^urous sea-far^ers, the monopoly was broken and clove plants were introduced into many places with varying results; a brief summary of the most important introductions is given here, it does not make any attempt at being complete.

THE UNIVERSITY OF CHICAGO

PH.D. THESIS

BY

JOHN H. ...

IN CANDIDACY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF ...

CHICAGO, ILLINOIS

19...

...

...

...

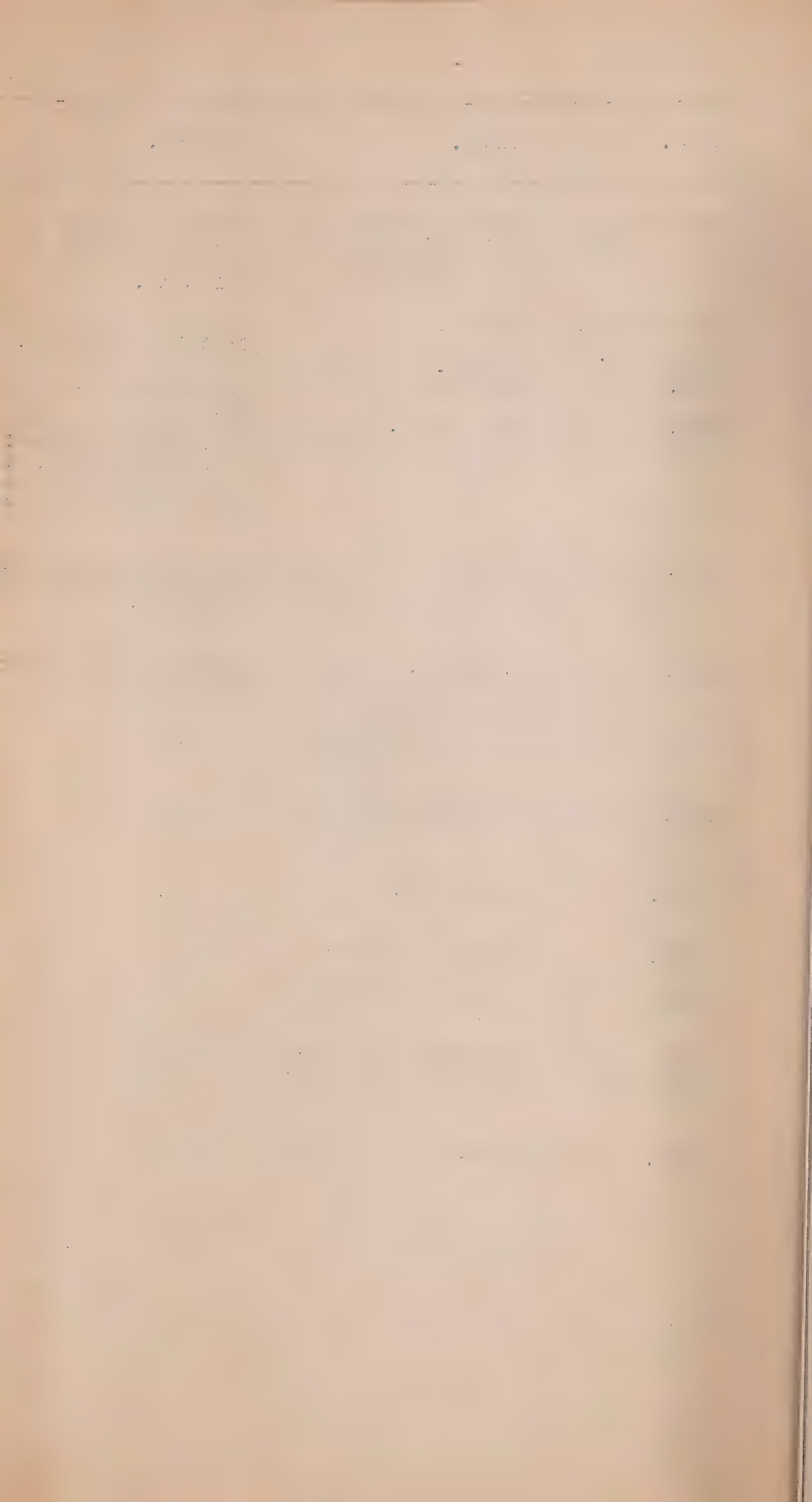
...

...

...

...

...



At the present time the clove:of commerce are produced by Zanzibar 9/10, Penang, Amboyna and Madagascar. The failure, to produce cloves commercially in the other countries into which they were introduced, is attributed to cyclones, lack of labour, disease, the irregularity of the crop and the consequent substitution of such a crop as sugar.

There is ^{no} authentic record of the introduction of the clove into Zanzibar, but ^{it} is commonly believed that it was brought from Mauritius in 1829 by a returning Arab exile, Harameli bin Saleh, who presented some seedlings to the Sultan Seyyid Said and in return was pardoned for his misdeeds. There is no doubt that extensive plantations were made in Zanzibar, soon after 1830, at the instance of Sultan Seyyid Said and it is owing to his foresight and influence, that the clove was also planted in Pemba.

An enormous amount of slave labour must have been used to establish and develop the clove plantations, the clearing of the forest land and planting in regular rows alone was ^a gigantic task and was extraordinarily well carried out by the Arab overseers. According to tradition and the evidence of freed slaves the shambas were kept in a high state of cultivation and were ~~being~~ continually extended. Present Arab owners have told me, that in spite of this, even in the far off days of their grand-fathers, when slave labour was abundant, clove trees would die suddenly, without apparent cause, just as they do now.

In 1872 a cyclone, which escaped Pemba, swept away most of the clove trees in Zanzibar, and that island had in consequence to be replanted. A large number of the trees in Pemba are therefore about ninety years old and these in Zanzibar not more than fifty years of

of

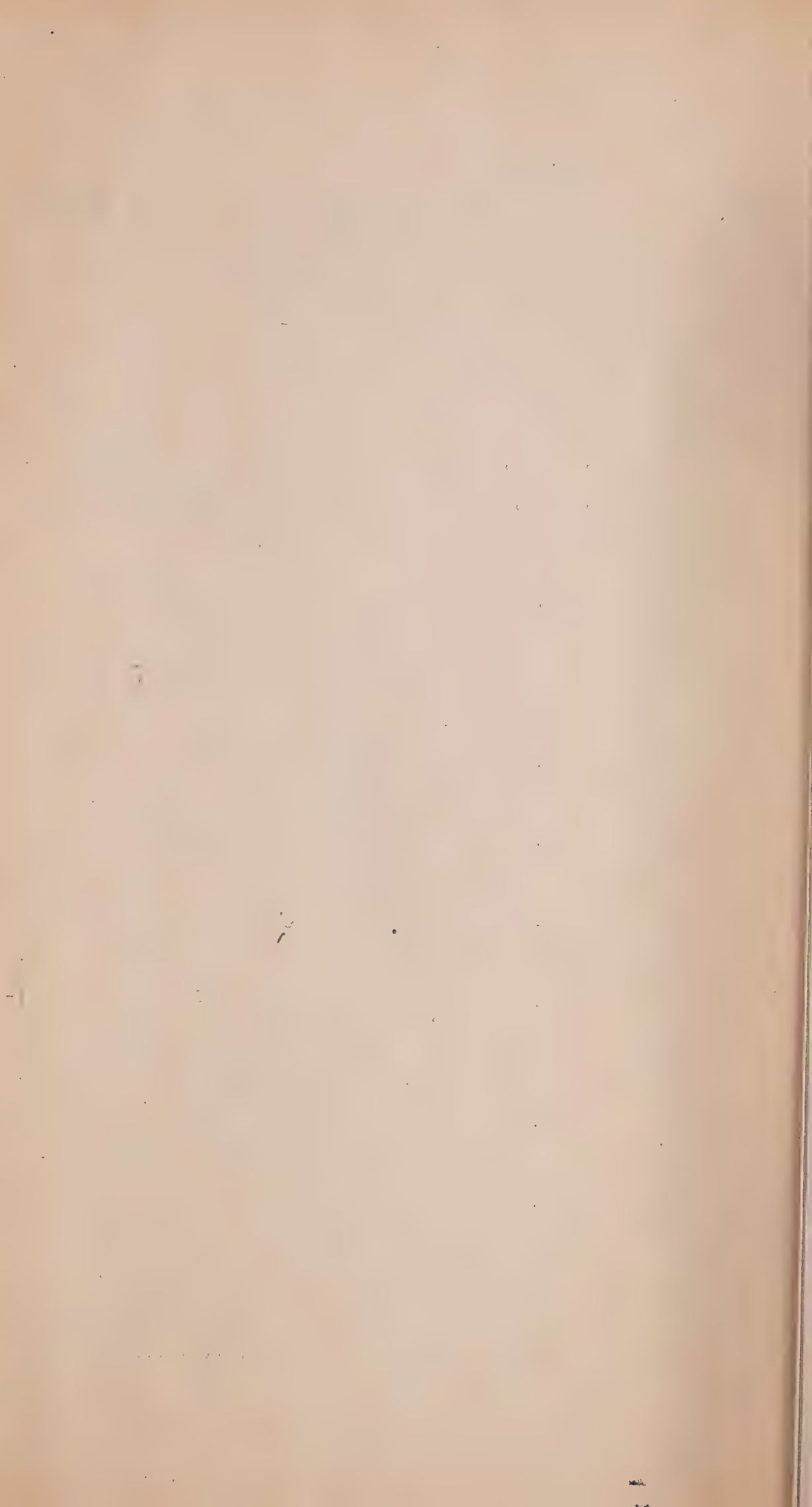
of age.

The present condition of the majority of ^{the} shambas is very bad and is undoubtedly partly due to the abolition of slaves and the consequent difficulty that the impoverished and unbusiness-like owners have in ~~what~~ obtaining sufficient labour to cultivate their estates.

Safaris taken through the clove districts of Mwera, Selen, Dunga, and Makue in Zanzibar and Mtangani, Weti, Mkoani and Fufuni in Pemba at the present time reveal certain notable facts:-

1. Mature trees are dying suddenly in both islands, the deaths commonly occurring ⁱⁿ the immediate proximity of previously dead trees.
2. Areas of dead trees are more numerous as well as larger in Pemba than in Zanzibar.
3. These deaths commonly spoken of as "Sudden death" occur in a variety of soils and aspects
4. The deaths are especially noticeable during a drought and immediately after heavy rains.
5. Very many trees in both islands are conspicuously disfigured with dead twigs and branches, a condition known as "die back".
6. "Die back" is especially common in damp areas and in districts exposed to strong wind.
7. Young trees, except where they are suffering from neglect and injudicious planting, are very free from symptoms of disease.

During recent years the number of deaths among clove trees is said to have increased enormously and alarming reports have been submitted to the Government. In going through the country the dead trees are most noticeable as they are seldom cut down by either Arab or



or

Swahili owners and the gaunt white branches are very conspicuous among the dark foliage of healthy trees. The yearly percentage of death trees is difficult to estimate owing to the inaccurate information supplied by shamba owners. For instance, recently, certain natives ^{when asked to make a return} were found to include in their total, trees which died in a previous year as well as trees which they thought would die, but which eventually recovered. Even taking these facts into consideration, the rate at which the clove tree is dying is a very serious menace to the revenue of the country.

2. Previously suggested causes of death.

The death and deterioration of the trees has been attributed in the past, to various causes, chief among which are drought, bad soil conditions especially water logged soil, neglect and old age. The various suggestions ~~the~~ will be briefly examined.

1. Drought. Warburg (22) in 1898 attributed the bad condition of the trees to drought and this factor is now commonly believed to be responsible for the present state of many of the Shambas. ^{It is} ~~This~~ undoubtedly a fact that trees die from drought every year in both Zanzibar and Pemba, ^{but} ~~but~~ especially in the ^{former} ~~later~~ island. In Pemba, where the land consists of series of low hills and valleys, the soil is often washed away from the steep slopes and the lateral roots of the clove are partially uncovered so that they are unable to resist even a slight drought. Again, both Arabs and Swahilis often plant trees in unsuitable places such as high ridges exposed to both sun and wind; in a drought these trees suffer badly from excessive sun and wind as well as from shortage of water due to drainage and they often die. Examples of such planting can be seen in many places.

During a drought or even during a normal hot

hot

season a large number of trees under five years old die from neglect; in the slave owning days, young plants would have been watered during a dry period, under present condition the native owner does not employ the necessary labour.

A number of dead and dying trees, growing in positions which indicated that death was solely due to drought, were carefully examined ~~examined~~ and compared with trees which also died during the drought but which were situated in well watered land but at the periphery of areas devastated by "Sudden death". A marked difference was found in the roots of the two groups. The trees which had died in dry but healthy areas had numerous brittle fibrous roots, those on the contrary from dry diseased areas, had very few fibrous roots.

It appears quite certain, that, even in normal seasons, a considerable number of young trees and trees planted in exposed positions die from drought but it is equally certain that drought does not account for the majority of deaths or for the symptom known as "Sudden death".

Exposed positions open to the East are specially bad.

II. Bad soil conditions. ~~44~~ Bad soil conditions, a very comprehensive term, has been thought to be responsible for the present condition of the clove. In 1913 when reporting on soils sent for analysis, ^{the} Director of Imperial Institute (13) suggested that this was the cause of the trouble; this opinion was again confirmed in 1919 by Dowson (8), ~~my~~ Mycologist to British East Africa, who was sent to Zanzibar to make a brief examination of the shambas.

There is ^a ~~a~~ consensus of opinion that the clove, like many other members of its natural order, is unusually sensitive to the presence of ground water, this opinion

opinion

is supported by the fact that certain trees are reported by Ridley (19~~3~~ page 164) to have died in the Singapore Botanical Gardens when their tap roots had reached ^an impervious layer of soil. Trees showing the typical characteristics of sudden death have been carefully excavated in the shambas of Makondeni, Weti, Tundaia and Fufuni and compared with healthy trees in these and other shambas. The top roots were dug up and at least a foot of soil removed from below the extreme tip; in no case was there any indication that death ~~was~~ due to a water-logged condition of the soil in these shambas. Mahon~~da~~, and some other shambas have not yet been examined, they are believed to be waterlogged and will be reported on later. The tap root of certain large trees examined in Pemba shambas and presumably about 80 years of age, varied in length from twelve to twenty feet, they either terminated in a fine fibrous end or in a bunch of fibrous rootlets. In most of the trees the roots grew almost straight downwards, but in those at Fufuni, this was not the case. Here, the roots had grown straight, had then turned sideways and downwards for a greater or less distance as they ^{went} ~~past~~ through a particularly sticky layer of soil, and finally, having penetrated this, the tap root went sharply downwards and ended in a fine hair like root which had every appearance of being perfectly healthy.

In many shambas the ^usurface three or four inches of soil consists largely of decaying leaves and twigs and immediately beneath this ^a ^{is} it/close and hard. The soil in the older shambas has been ^Lpresumably, not disturbed, except just on the surface, for many years. The cultivation at present done with the native hoe does little more than destroy the weeds and stir up the decaying humus on the surface; no manure, beyond the naturally fallen leaves and decaying weeds is added and as a result the



the

soil has gradually become impoverished as well as badly aerated. In the Straits Settlements Van Gorkom (11) states that cow-dung, fish offal, or slowly burnt earth ~~are~~ used as manure.

Analyses of soil~~s~~ surrounding healthy and diseased trees in the Weri Shambasa were carried out in 1921, at the request of this department, by the Imperial Institute of the United Kingdom, the Colonies and India. They show that the difference in the soils is not sufficient to account for the death of one tree whilst its neighbour remains healthy. The report states that the analyses show moreover that "there is no doubt that both the series of soils would benefit by treatment with lime in order to ^unetralise the acidity, followed some~~x~~ weeks later by the application of a good phosphatic manure". Details of the analyses are set out and are seen to be in conformity with analyses made in 1916 and 1917 of various soils in Pemba. In all the cases it was found that the soil^s in both devastated and healthy area^s were acid and lacked ~~any~~ and phosphates.

These analyses show that the symptoms known as sudden death and die back are not due to the constituents of the soil, but suggest, that the unfavourable soil conditions may be a contributory cause, in so far, as they inhibit healthy root action.

Poor aeration of the soil is very common in Pemba and reacts most unfavourably on the root development of the clove. At Makondeni and other Government Shambas in the Weti districts, the soil is in bad condition, there is a loose surface layer of 3 or 4 inches of decaying ~~xxx~~ leaves and twigs mixed with a little soil and below this the soil is very close ⁱⁿ texture and ^{is} badly aerated. As a result, the fibrous roots lie very close to the surface and are very susceptible to drought and injury. At the Tundaua and Fufuni Government shambas the soil is in much better condition, there is a considerable depth of well aerated surface soil. The lateral roots are well buried and the all important fibrous roots are able to ramify in good aerated soil which affords them adequate food and protection. In both these shambas, the upper layer of soil contains a fair proportion of sand, the lower soil being the rich sticky loam so favourable to the clove. It is possible that the good soil aeration is responsible for the high quality and quantity of the cloves produced from these two shambas. The absence of good aeration does not ^o however account for the presence of sudden death, unfortunately this disease is found in both the Tundaua and Fueni shambas, though it is spreading there much more slowly than in the Weti district. In the Weti district where aeration in most shambas is bad the fibrous roots are forced to grow in the top layer of decaying leaves where they are especially exposed to the attacks of animals and injurious fungi.

Neglect of proper cultivation.

~~18~~ Neglect of proper cultivation. The ~~proper~~ neglect



neglect

of the shambas to which ~~causes~~ Dowson (7) partly attributes the numerous deaths, is undoubtedly a most serious factor in the situation and is at the bottom of ^a great deal of our present trouble. It is however, as I shall presently show, not the immediate cause of those deaths but a contributing factor of great importance. The chief items of neglect will ^{be} dealt with in turn.

(a) Weeding. It is the custom in the Protectorate to weed a shamba twice a year; one annual weeding in most places, is insufficient to keep the ground even approximately clean; three weeding^s on the other hand, are said to be in most ^cases unnecessary and owing to the expense of labour economically unsound, though of this I can give no opinion. In Zanzibar, the weeding^s are fairly regularly carried out but in Pemba, comparatively few shambas are weeded more than once a year and many are not weeded at all. As a result, the soil is exhausted and the trees are chopped and seriously weakened, making them more liable to succumb to adverse conditions. The present Ak^uda of Weti, a man of about 70 years of age, has passed all his life on the clove shambas and ^{was} for a long time a Government overseer. He tells me, that when he was a boy, most Arab owners kept two slaves to every fifteen trees, it ~~was~~ their duty to weed constantly and to cultivate much more deeply than is done at present. The chopping and weakening of the trees is not the only damage caused by insufficient weeding; some of the neglected weeds grow into bushes, and when they are eventually stubbed up, many of the thick roots rot in the ground and harbour parasites. There is evidence to show that in some cases, when the ground was originally prepared for planting, it was not thoroughly cleaned and ~~wooden~~ roots were left in the ground which provided a home for fungi. Similarly the trees which die now are usually allowed to rot in the ground and few shambas can be found in which there are no rotting trees.



Another result of uncleared ground is that it harbours white ants and these creatures not only attack clove seedlings in the nurseries but also damage trees. Sometimes they seriously enlarge wounds in the trunk caused by broken branches; ~~at~~ other times they build their nests among the roots and may be found tunnelling into the thicker roots. It is not uncommon to find a circle of ant "balls" surrounding an unhealthy tree, they are usually ~~placed~~ ^{found} just at that point where the fibrous roots are most numerous. Ants seldom attack healthy trees but they do much damage to those that are weakly, and in any way injured. One of the most troublesome, is the "^hCungu-uvundo", its presence can generally be detected by its strong and disagreeable smell. Owing to their habit of building only a little way below the surface of the ground, the ants are seldom much trouble in well cultivated ~~shambas~~ ^{te}. Infested trees have been found at Makondeni, Fuent and Wakf shambas in the Weti districts, as well as at Selem in Zanzibar.

(b) Pruning. Warburg (22) in 1898 states that in his opinion one of the causes of the deterioration of the clove trees in Pemba was the lack of sufficient pruning. In the Moluccas, trees are pruned, according to Van Gorkom (11), to keep them low; Key (15) states that in his shamba at Kizimbani, Pemba, pruning strengthened the trees. At the present time no pruning is done in ~~either~~ ^g Zanzibar or Pemba by native owners and in the time at my disposal it has not been possible to investigate this question. The few experiments I have made in this direction were performed on old unhealthy trees with a view to regeneration, and suggest that further work might be valuable. Diseased trees have been greatly improved by

- (a) cutting out all dead wood and damaged trees. *twigs*
- (b) thinning weak branches.

The question of pruning young trees in order to

... ..
... ..
... ..
... ..

... ..
... ..
... ..

... ..
... ..
... ..
... ..
... ..

... ..
... ..
... ..
... ..

... ..
... ..

... ..
... ..
... ..

... ..
... ..
... ..
... ..
... ..
... ..

... ..
... ..

to

keep them strong and free from disease has not been investigated, as it is known that the Director of Agriculture has, for some time past, been experimenting¹²⁹ in this subject.

The effect of neglect is easily seen if two Pemba shambas, such as those of Makue and Mtemani near Weti, are compared.

~~The~~ ^{The} small shamba belonging to binti , the wife of Nasor bin Suleman at Mtemani, consists almost entirely of old trees but is in good condition. It has been in the present owners family since it was planted about seventy years ago and is now in the personal care of the owner's husband and brother-in-law who live on the shamba. The work is done by relations and a small number of labourers who are regularly employed, extra help only is required for harvesting²². Nasur bin Suleman says that he is not able to cultivate the shamba as well as was formerly done, but the ground is kept clean and dead branches are not to be seen; the trees bear well and the shamba is stated to be profitable. The shamba is a good example of the results to be obtained by constant intelligent supervision.

The Makue shamba is a striking contrast; the trees are about the same age as those at Mtemani, a very large number of them are dead, the remainder do not bear well and are obviously dying. The tale of misfortune and neglect is unfortunately that of many other shambas in Pemba.

The shamba was planted by Hamadi about 1835 and at his death was divided between his son Saleh and his daughter. In 1896 civil war broke out and Saleh took the side of Khaled bin Barghash and as a result his portion of the shamba was confiscated by the victorious

1870

1871

1872

1873

1874

1875

1876

1877

1878

1879

1880

1881

1882

1883

1884

1885

1886

1887

1888

1889

1890

1891

Victorious

Sultan Seyyid Hamoud. Instead of being cultivated by 300 slaves, the shamba was almost abandoned; it was in the charge of an Arab Governor Hamid bin Thinei El-Suheli but owing to its inaccessability it was seldom visited by any overseer and ^{was} very rarely weeded. In about 1900 "Sudden death" made its appearance and since that time the disease has steadily spread.

The neighbouring portion belonging to Binti Hamadi was hardly more fortunate. The owner died soon after her brother's misfortune, and during the long minority of her son very little was done to the shamba. Disease spread from the neighbouring shamba and there is now, on the two portions a loss of about 350 trees out of a total of 1000 originally planted.

IV. Old Age. It has been suggested that the "Sudden death" is ^emerely the result of old age and is a normal phenomenon. This is not borne out ^fif the diseased areas are examined. It is certainly the case that more very old trees succumb to the disease than do middle aged ones, and that seedlings and young trees seem to be ^{more or less} immune but trees of thirty to forty years of age die of sudden death as well as those of ninety years of age.

The limit of ~~the~~ age of the clove tree is not known; vigorous bearing trees of over ninety years of age are common in Pemba and these trees have certainly not reached their maximum age. One writer states that they ^{are} known to live for over one hundred and thirtyfive years.

When sudden death occurs in a shamba, it is the old trees which succumb most readily. This ^{is} probably because ^{any} ~~only~~ conditions effecting the water supply adversely would be less easily compensated for, in a tree with a very large amount of leave ^f surface.

The foregoing account shows that though the

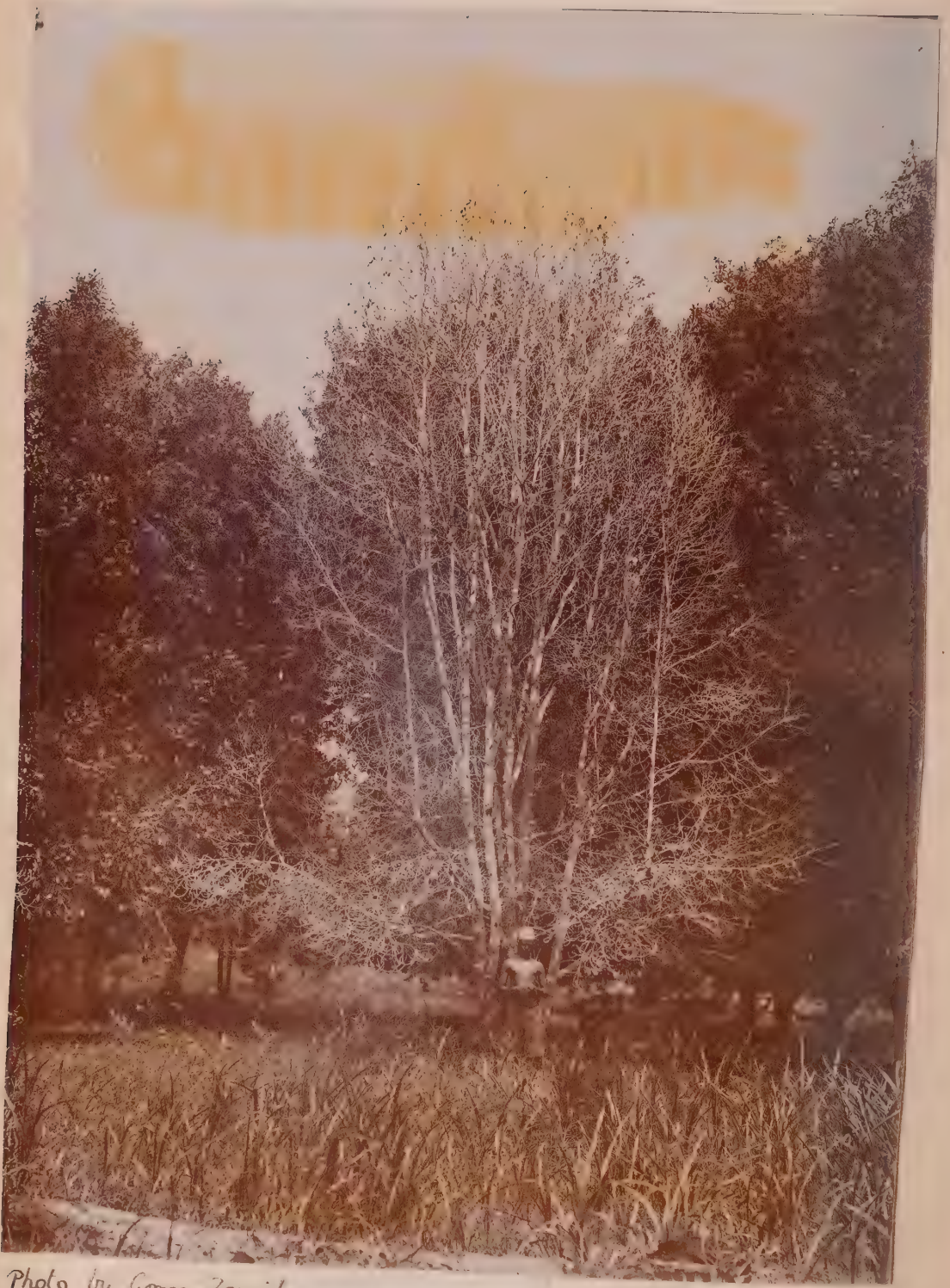


Photo by Gomes, Zanzibar

A diseased clove tree at Marseilles Shamba, showing the appearance of "sudden death"

the

conditions in the two islands are very unsatisfactory they are not primarily responsible for the death of the trees.

Diseases of the Clove. Amicroscopical examination has been made of the root, trunk, twig and leaf of both diseased and healthy trees, and as a result it has been found that certain fungi are present in the tissues of the diseased trees. Two distinct diseases have been found, one caused by the Ascomycete, Peziza caryophyllata spec nov*, takes the form of a root rot and produces the symptoms commonly spoken of as "Sudden death"; the other Diplodia eurenoides* ^{is} parasites the leaf, causing a "die back" of the twigs.

I Root Rot. The root rot disease is more abundant in Pemba than in Zanzibar, probably because the shambas there are more neglected and contain many rotting tree stumps. Peziza caryophyllata, like certain other parasites^{ic} fungi, such as Botrytis cineria, is capable of living saprophytically on decaying matter, it is found on rottenⁿ twigs and leaves in the soil but when growing vigorously, as it usually does after the rains, it is able to attack damaged fibrous roots of the living clove tree. At first it grows in the cortex, often causing this tissue to separate entirely from the central cylinder, gradually however, it penetrates into the wood and destroys the root. The fungus spreads slowly backwards from the periphery^{ic}, till finally, the main lateral roots and even the trunk are invaded by the parasite^{ic}. The destruction of the fibrous roots is very thorough and when accomplished, results in the death of the plant. If the roots of a recently dead tree^u are ^uuncovered it will be found that many of the finer fibrous roots have disappeared, others have been reduced to thin wire-like threads, owing to the removal of the cortex, the thicker roots are dry with

Both these fungi have been sent to Kew for comparison with type specimens, the names here given are only used for convenience

with

powdery and flakey bark which comes off with the slightest rough handling. The main thick lateral roots are also covered with a flakey bark and under certain conditions it will be found that parts of the outer layers readily separate from the central cylinder, often indeed, part of the woody tissue comes away with the bark, revealing a closely adpressed, white incrustation. This incrustation consists of a mass of mycelium, the hyphae of which are gradually penetrating further and further into the wood.

Under suitable conditions — sufficient water and air, this incrusting mycelium gives rise to minute black peziza like fructifications (Fig. 1 a & b) which liberate ^{or} innumerable small spores (Fig 1. c). I have found these fructifications very abundantly in different parts of Pemba in November and December, after the unusually heavy rains of this year.

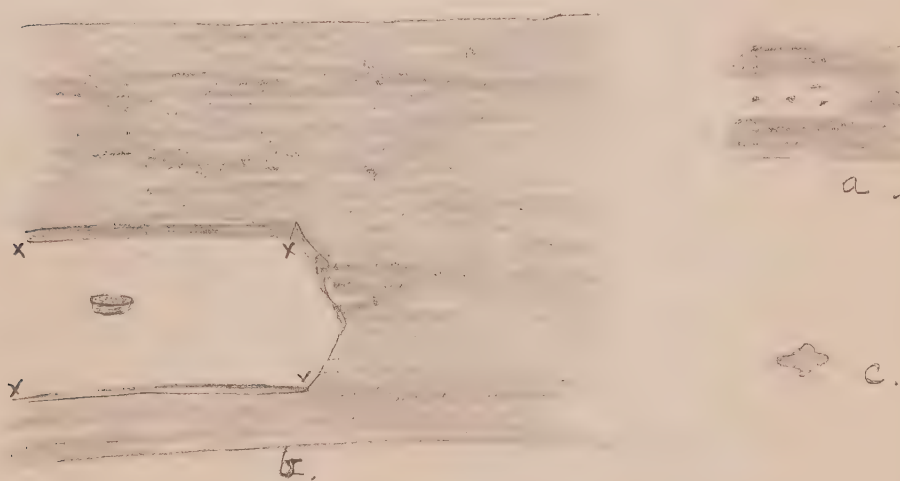


Figure I. *Peziza caryophyllata*

- a. Fruit bodies natural size
- b. Much enlarged. Part of the bark has been removed x x ~~fra~~ a shallow cup shaped fruit is shown.
- c. a single spore, very much enlarged.

When the fungus has entered the root it grows very rapidly, passing through the walls and living on the cell contents (figure 2). As a result of pressure exerted by the growing hyphae many of the cells are broken down and the fungus may become inter²cellular at any rate
^

The first part of the paper is devoted to a discussion of the general principles of the theory of the structure of the atom. It is shown that the structure of the atom is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

In the second part of the paper, the author discusses the question of the structure of the nucleus. It is shown that the structure of the nucleus is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The third part of the paper is devoted to a discussion of the question of the structure of the molecule. It is shown that the structure of the molecule is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

In the fourth part of the paper, the author discusses the question of the structure of the crystal. It is shown that the structure of the crystal is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The fifth part of the paper is devoted to a discussion of the question of the structure of the solid. It is shown that the structure of the solid is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The sixth part of the paper is devoted to a discussion of the question of the structure of the liquid. It is shown that the structure of the liquid is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The seventh part of the paper is devoted to a discussion of the question of the structure of the gas. It is shown that the structure of the gas is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The eighth part of the paper is devoted to a discussion of the question of the structure of the plasma. It is shown that the structure of the plasma is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The ninth part of the paper is devoted to a discussion of the question of the structure of the vacuum. It is shown that the structure of the vacuum is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The tenth part of the paper is devoted to a discussion of the question of the structure of the universe. It is shown that the structure of the universe is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The eleventh part of the paper is devoted to a discussion of the question of the structure of the world. It is shown that the structure of the world is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The twelfth part of the paper is devoted to a discussion of the question of the structure of the life. It is shown that the structure of the life is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The thirteenth part of the paper is devoted to a discussion of the question of the structure of the mind. It is shown that the structure of the mind is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The fourteenth part of the paper is devoted to a discussion of the question of the structure of the soul. It is shown that the structure of the soul is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The fifteenth part of the paper is devoted to a discussion of the question of the structure of the spirit. It is shown that the structure of the spirit is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The sixteenth part of the paper is devoted to a discussion of the question of the structure of the universe. It is shown that the structure of the universe is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The seventeenth part of the paper is devoted to a discussion of the question of the structure of the world. It is shown that the structure of the world is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

rate

for a time.

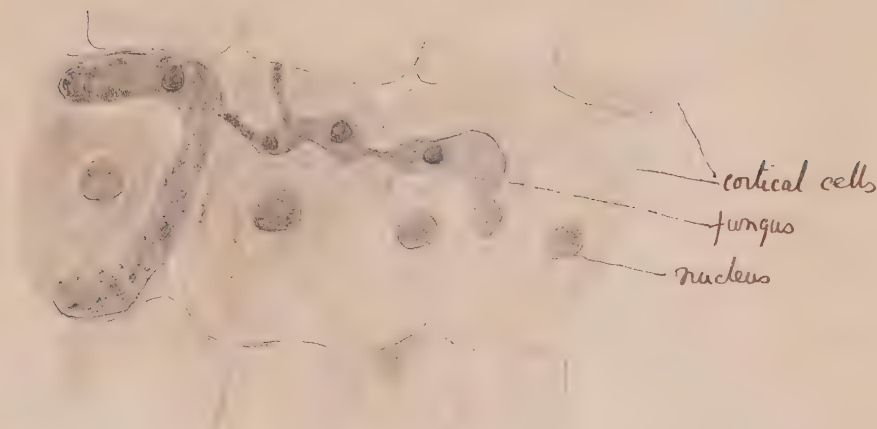


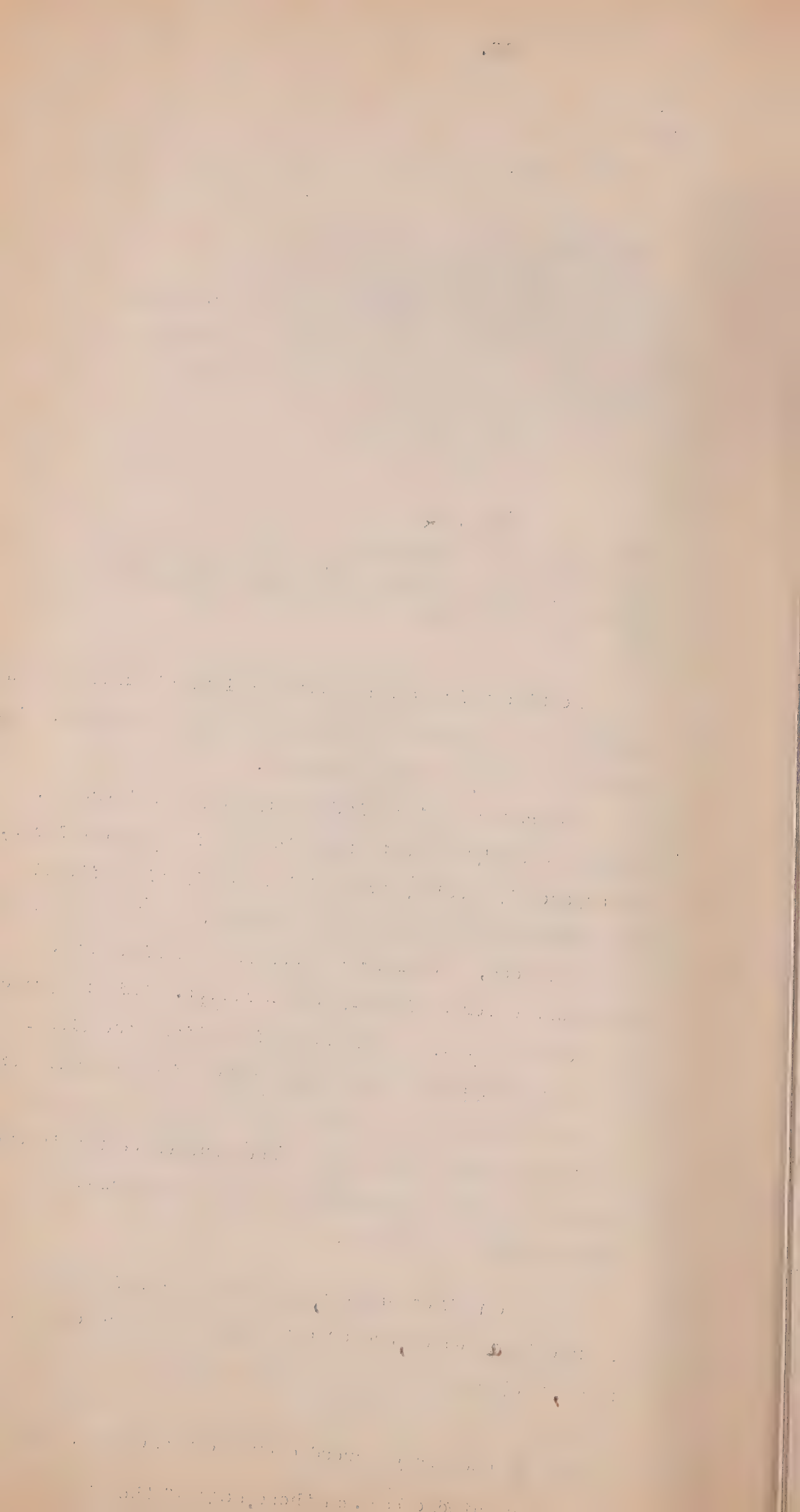
Figure 2.

Root-rot fungus - Sketch showing cortical cells invaded by the mycelium, the hypha has passed through the wall of one cell to another

The time which elapses between infection and death appears to be variable and to often exceed one year, ~~and~~ indeed, it ^{is} probably usually does so.

The course of the disease may vary considerably. "Sudden death", the most dramatic form, is the best known. An apparently healthy tree will suddenly wilt without any warning and in two weeks time may, to all appearance be quite dead, the branches standing out like white skeletons covered with dry brown leaves. This is probably the result of many simultaneous infections due either to the liberation ^{at} of the fungal spores ^o in the ground or to the proximity of a number of ~~a~~ rotting roots of a previously dead tree; in any case "sudden death" is due to the stage of disease having been reached, when the water supply is cut off.

It sometimes happens, that only one main branch of a tree is affected, and an examination will reveal the fact, that only part of the root system has been involved. I have found other cases of trees with a considerable amount of dead wood spread over the whole tree, giving the effect of die back, on these, many of the fibrous roots



roots

had been destroyed but there still remained sufficient^{-nt} to keep the tree alive, many of them ^ebeing new rootlets produced to compensate^a for those destroyed.

It is, I think, a safe generalisation to state that the older the tree, the greater and quicker is the damage wrought by the fungus. This is I believe due to the fact that vigorous mature trees are capable of producing new rootlets to take the place of those destroyed^{yed} by the fungus. This power of recuperation may even be the reason why young trees and seedlings appear to be immune to root rot.

Many attempts have been made to induce the fungus to grow on agar in tube cultures, so far these have failed though the attempts have resulted in the isolation of several saprophytic forms, some of which are new to science and have been sent to Kew for naming.

Experiments have been made to test the effect of artificially innoculating seedlings with infected roots. One of these treated plants became very unhealthy and dropped nearly all its leaves, but it is now recovering and producing new shoots. Such a result of course is no proof that the plant had sudden death and the experiments are to be repeated on a larger scale.

Experiments are being carried out at Makondeni with the view of ascertaining to what extent seedling clove trees can be safely planted in infected ground. So far the plants are doing well and there are no signs of disease in any of the plots.

Plot 1. Ground full of dead clove roots. Weeded and treated with 1 lb of lime to every square yard. Seedlings planted Aug. 1921.

Plot 2. As plot one, but lime omitted.

1892

To the Hon. Secy. of the Interior
Washington, D.C.

Dear Sir:

I have the honor to acknowledge the receipt of your letter of the 10th inst.

and in reply to inform you that the same has been forwarded to the proper authorities for their consideration.

I am, Sir, very respectfully,
Your obedient servant,
J. M. Smith

Very truly yours,
J. M. Smith

Enclosed find the same as requested.

Plot 2. As plot one but lime omitted.

Plot 3. Ground full of dead clove roots, they were exposed as much as possible ^{then burnt,} the ashes being scattered and hoed ⁱⁿ the soil. The seedlings were planted in April 1922 and top dressed with basic slag in June 1922.

Plot 4. Ground was full of dead roots but has been trenched and as many as possible of the roots removed. It will be planted in April 1923.

Observations have been carried out at Makondeni, Weti and Tundaa to ascertain the rate and method of infection. In each case the majority of new cases have been immediately adjacent to dead stumps, and infection has been carried by contact. In all these places the roots of mature trees normally grow so far in a horizontal direction that they interlace with their neighbours, there is thus little chance, if one tree becomes infected, that its neighbours ^{will} ~~shall~~ escape. When the disease has occurred on sloping ground the infection usually spreads first in a downward direction. At Fueni, the disease has broken out in a new area and the surrounding trees are being carefully watched for the first signs of disease so that the interval which occurs between infection and death may be roughly judged. This fresh out-break of disease may be due to the presence of ^Umycelium in the soil or to a fresh infection from spores. Spores have been produced in abundance only a short distance away and owing to their small size and rough edges (See fig. 1.c) they can easily be carried by such insects, as ants, which abound in the locality and are especially numerous on diseased trees. ^{Spores} The ~~spores~~ develop slowly in artificial cultures and are saprophytic, they can thus germinate in the soil and develop the hyphae necessary to cause infection.

Prevention.

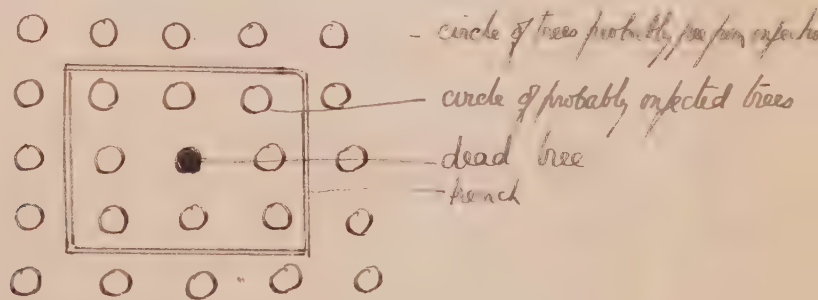
The source of infection is present in the form of fungal mycelium in the soil and in the decaying stumps of

of

trees. The most successful method of dealing with the fungus would therefore be the complete removal of all stumps and roots and the partial sterilisation of the ~~xx~~ surface soil to a depth of 12 inches by means of chemicals e.g. formalin. It is obvious that such a method is too expensive to be economically sound ^{for} a crop like the clove.

The following method to prevent the spread of infection has been tried in several places and so far has ^{been} satisfactory.

The infected tree has been cut down and removed, and the stump and main lateral roots burnt to destroy all ~~x~~ spores. The stump and its immediate surrounding neighbours, eight trees, have been isolated by means of a trench 3 ft deep, all roots met with being ^Cut through and removed. By this means, the neighbouring ^E tree roots when they in their turn become infected are unable to pass on the disease by means of mycelium growing from one root to another. At the same time efforts have been made to improve the condition of the trees immediately outside the circle of infection; they have been well hoed, lime at the rate of 1 lb to the square yard has been applied, and dead wood and weak growth has been removed.



Plan showing method of isolation

Where disease breaks out in a new area, it ~~w~~ould be ~~xx~~ advisable to cut down the eight trees surrounding the dead tree but of course this means the loss of one, if not two, crops of cloves;

1. The first part of the paper is devoted to a general
discussion of the problem. It is shown that the
problem is well-posed and that the solution is unique.
The second part of the paper is devoted to a
detailed study of the properties of the solution.

2. The third part of the paper is devoted to a
study of the asymptotic behavior of the solution.
It is shown that the solution tends to zero as the
parameter tends to infinity.

3. The fourth part of the paper is devoted to a
study of the stability of the solution. It is shown
that the solution is stable with respect to the
initial data.

4. The fifth part of the paper is devoted to a
study of the numerical solution of the problem.

5. The sixth part of the paper is devoted to a
study of the physical interpretation of the results.

6. The seventh part of the paper is devoted to a
study of the applications of the results.

7. The eighth part of the paper is devoted to a
study of the conclusions.

there is little chance that these trees will have failed to contract the disease and if so they are unlikely to survive for more than ^{one} or two seasons.

As regards infection the spore stage is the most dangerous one. It is therefore most important that the disease should be recognised before the spores reach maturity. The fructifications are only developed on the collar and main roots near the surface of the soil, air being necessary for their formation. Care must therefore be taken that these portions of a dead tree ^{are thoroughly charred.} ~~cleared.~~ Similarly, if any of the more deeply buried roots are dug up, they must be burnt and not allowed to produce spores or to spread mycelium in the soil.

Cure. If a tree has become diseased to such an extent that the main roots or trunk are infected, there is no possibility of cure known to us. In early stages of the disease, however, much can be done. Certain trees at Makondeni looked very sickly and were found to have diseased fibrous roots. They were treated in December 1921 and now appear to be healthy but of course, it is as yet too early to determine if the improvement is a permanent one. The course adopted was as follows:-

Many of the roots were uncovered and all diseased roots removed and burnt; the soil was then thrown back well mixed with lime; all dead and weak wood was cut away; the ground was again hoed after an interval of 4 months. If the production of new roots can be encouraged in sufficient quantity to compensate for loss by disease, there is certainty of prolonging the life of the tree indefinitely.

It is doubtful if lime, when applied at the rate of 1 lb to the square yard, has a deleterious action on the fungus, its beneficial effect appears to be ^{at} rather that it causes an increased vigour of the root system. Whether this actually prevents infection it is impossible to say in an experiment lasting only twelve months; it may be only of

of

temporary benefit enabling the plant by its increased ~~vigour~~ vigour to produce new roots to compensate for those already attacked; even if this is so, it is economically valuable, in that it lengthens life and enables the tree to produce extra crops before death occurs.

The beneficial effect of liming lasts for many years and this should be taken into consideration when considering the cost of the treatment.

At Makondeni the cost worked out at 1 rupee per tree for an area of 148 trees, the trees being 21 feet apart.
equal to 100 rupees an acre

80 bags of lime bought at Mtambue Mkuu	
and taken to Weti.	60. 00
transport over 4 miles of rough path.	60. 00
Wages for spreading & hoeing ground.	28. 50
	<u>148. 50.</u>

In this case the cost of transport was exceptionally high, as the road in places was impassable for carts. The cost of labour too ~~was~~ was unusually high, labourers having to be fetched from a long distance were given ~~posh~~ 10. The cost of hoeing should not be reckoned as additional expense as it ^{should} takes the place of one of the two periodical routine weedings.

Mr. O'Connor (17) has informed ^{me} that in 1907 there was a serious out-break of disease in Madagscar (St. Marie) which superficially at any rate, must have resembled the Zanzibar disease. It has not ~~recovered~~ and young plants put into the infected ground have remained healthy.

Ridley (19) mentions that in Malacca in 1894 a clove tree died of a fungus disease of the roots, it was not identified and the description given of it suggests that it was different to that found in Zanzibar.

Summary. Sudden death is due to a fungus Peziza

... ..
... ..
... ..
... ..
... ..

... ..
... ..
... ..
... ..
... ..

... ..
... ..
... ..
... ..
... ..

... ..
... ..
... ..
... ..
... ..

... ..
... ..
... ..
... ..
... ..

Peziza

^o
caryophyllata spec Nov. which causes root rot. It first attacks the fibrous roots and then spreads to the main root and trunk. It occurs chiefly in old trees in shambas which have been neglected and contain the rotting roots of trees and shrubs. All cases should be promptly dealt with by:-

- (1) cutting down and removing dead trunks.
- (2) isolating by means of trench.
- (3) burning stump and large lateral roots to destroy spores.
- (4) better cultivation of surrounding trees.
- (5) application of 1 lb to sq.yd of lime to trees round infected areas.

2. Die Back.

Die back is a very common symptom of disease in many plants and may be due to various causes. In Zanzibar and Pemba many trees look unhealthy owing to the number of dead twigs and branches which they bear. The first system of such an unhealthy condition is the fall of the apical leaves the trouble spreads backwards till gradually the shoot and branch ^{are} defoliated.

A gradually increasing lack of water caused by the slow development of root rot will produce the effect of die back as I have already shown (page 19) it is therefore necessary, should die back make its appearance ^{to search for the} of the root rot fungus, and if it is found, treat for that disease.

In a very large number of cases the die back is due to a leaf disease rather than to disease in the root. The disease in this case is caused by a fungus ^o provisionally named Diplodia eugenoides (see page 17), which enters ^{the stomata} the leaf through its tissues and spreads from thence to the twigs, causing leaf fall. The method of infection is peculiar and as far as is known, unique.

An alga Cephaleuros ^{Mycoidea} ~~virescens~~ is very common ^o in the tree trunks and leaves of various trees especially on mangoes ⁿ.

mangoes

and cloves and at certain seasons of the year, usually in June and December or indeed after heavy rains have ceased and when the air is moist the alga produces its fruits in the form of small round gonidia (fig. ³4).



Figure 3 Cephaleuros mycoidea

(a to d). Stages in the formation of the gonidia
(e) A ripe gonidium. All much magnified.

The ripe gonidia are easily detached and are carried by the wind to the surface of tree trunks and leaves, here they germinate and give rise to minute disks of cells which are closely adpressed to the surface of the plant (fig. ⁴5).

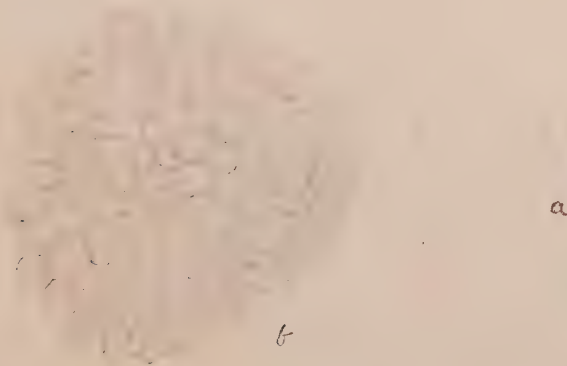
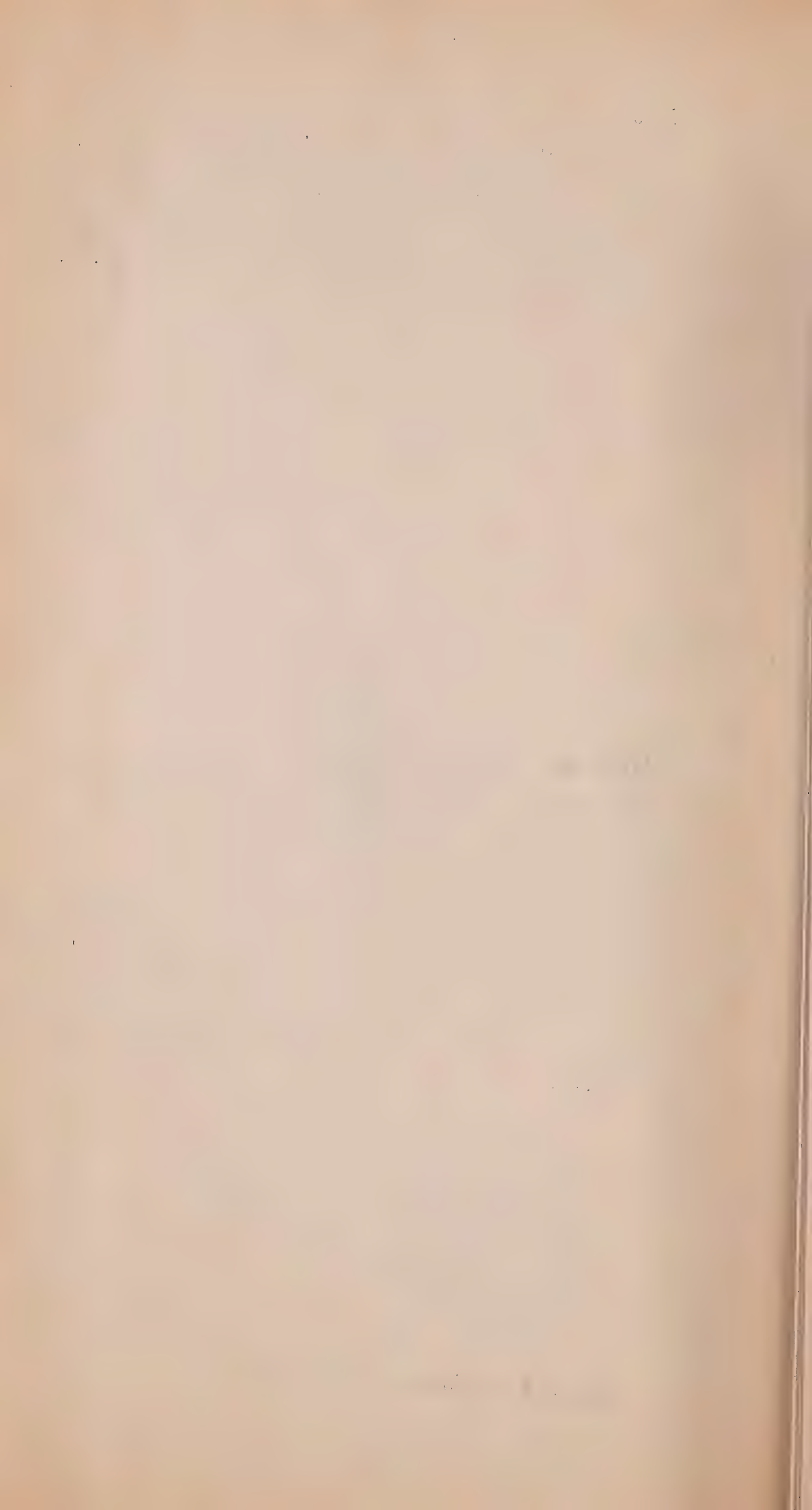


Figure 4 Cephaleuros mycoidea

a. Disk natural size
b. Disk much enlarged.



The alga^{the} does not enter the leaf and injure it, as it does in the case of leaf disease of the Singapore clove (Ridley 19¹) though it is often present in sufficient quantity to *choke* many of the stomates and so interfere^r with the normal function of the leaf. If the air becomes hot and dry the alga partially dries^L up, forming a film on the leaf and remain^Sing in this state during adverse conditions. When the air is moist the cells of the disk absorb water and swell till they become gelatinous. The smooth cuticle of the clove leaf affords small foot hold for any fungal spores which may be blown on to its surface; when however the spores are deposited on a moist algal disk they adhere readily to it, germinate quickly, and the young hyphae push through the stomates (figs. 5 & 6) into the interior of the leaf where they ramify through the cells of the leaf in search of nourishment.

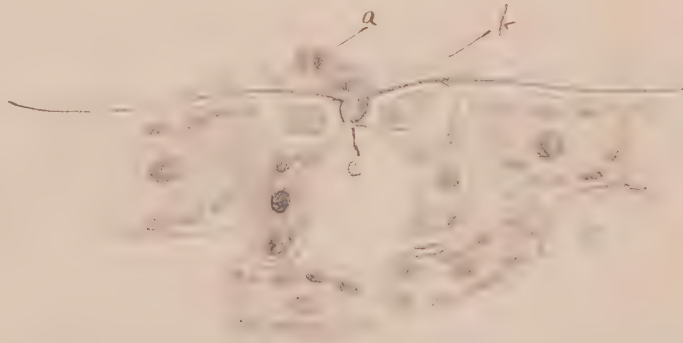
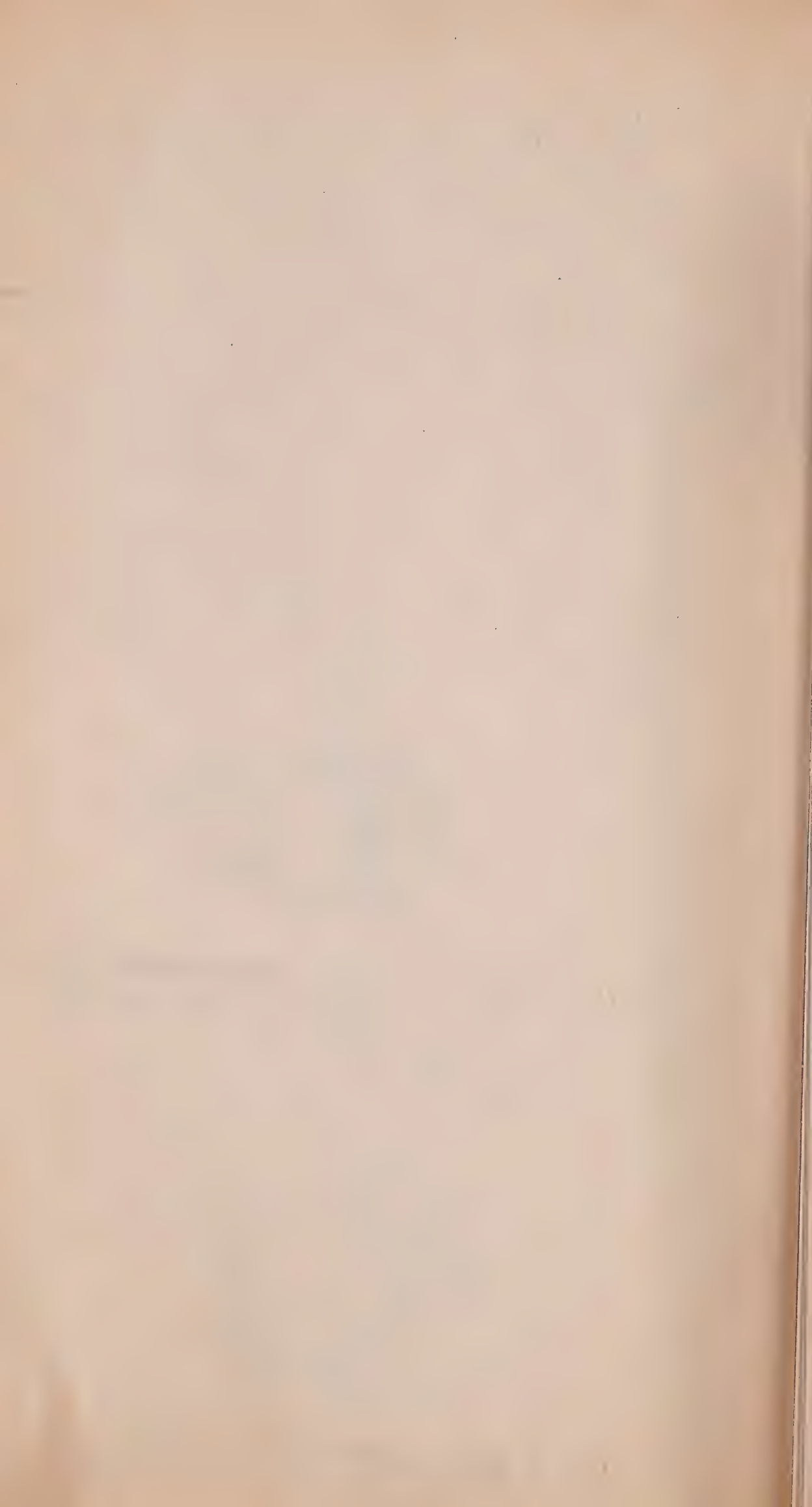


Figure 5. *Cephaleuros mycoideus* & *Rhizoglyphus* ~~*Rhizoglyphus*~~ *Diplodia rugonoides*
Transverse section of clove leaf showing actual infection through a stomate

a = the young fungal hyphae
b = the algal disk
c = the stomate



Figure 6 *Rhizoglyphus* ~~*Rhizoglyphus*~~ *Diplodia rugonoides*
Oblique T. section of clove leaf, showing a well nourished hypha entering the leaf through a stomate.



Gradually the inner tissue of the leaf is destroyed and the fungus forms pycnidia just below both the upper and the lower epidermis (fig. 7)

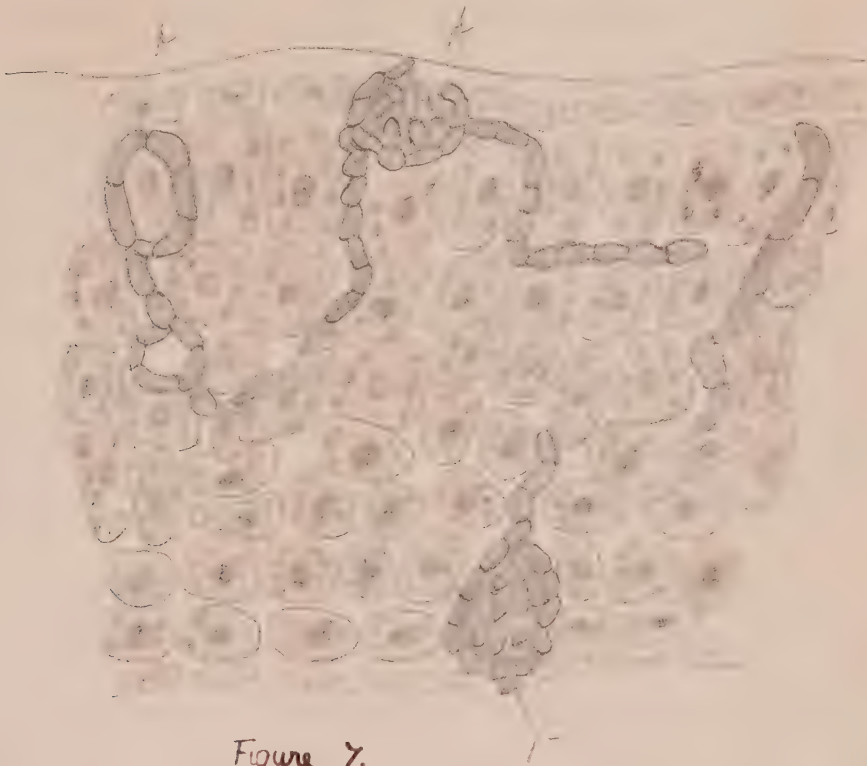


Figure 7.

Transverse section of a clove leaf invaded by the fungus which causes "die back". Pycnidia on various stages of development can be seen. p = pycnidium.

As the leaf dries the pycnidia break through the epidermis and the spores are scattered. This sometimes happens while the leaves are still attached to the tree and sometimes after they have fallen to the ground.

Observations in the Weti shambas have shown that the clove trees exposed to the wind are particularly liable to the combined attack of Cephaleuros ^{*Mycoidea*} ~~*Verexens*~~ and Diplodia ~~*eugenoides*~~, the wind carries the gonidia of the alga and this prepares the way for the more virulent fungus.

No ~~fungus~~ cases have been found of the occurrence of infection without the intervention of the alga. Ordinarily when any leaf becomes infected, the fungus spore germinates on the surface of the leaf and one of two things happens, either it grows into the leaf through a stomate

stomate

as in *Hemuleia vastatrix* ^{on coffee leaves} or it fixes itself to the leaf by means of swollen cells and using these as a fulcrum forces its way into the leaf by rupturing the cuticle such as in *Botrytis cinerea* (24), a common disease of the lettuce. The clove leaf presents a smooth hard surface to any spore; owing to the absence of hairs, and the dry atmosphere, very few spores would have the opportunity to develop sufficiently to enable them to seek the food and protection afforded by the interior of the leaf; the alga in the case of the clove provides the necessary foothold and moisture for germination and growth.

Cephaleuros ^{mycordeia} ~~*wirescens*~~ has been described by Ridley (19) as being the cause of disease in the Singapore cloves and also by Mann and Hutchinson (16 a) as causing Red Rust of Tea. Its life history has been fully worked out by Cunningham (6) and Karsten (14). They describe the alga as being epiphytic on many plants where it is harmless, but show that in other cases it actually penetrates the leaf, even reaching from one surface to the other. A very careful examination of the leaves of the Zanzibar clove has not revealed one case where the alga has penetrated the leaf.

Remedies:- Both the alga and the fungus can be destroyed in its early stages by the use of a fungicide such as the Bordeaux mixture of copper sulphate or Vermorel's preparation of copper acetate, diluted to $\frac{1}{2}$ the usual strength. It has been the custom in this country to allow the clove tree to grow unrestricted by pruning and as a result the mature trees are too tall to be efficiently treated with the small hand apparatus available. Experiments which deal only with part of a tree are useless as the treated area speedily becomes reinfected. Owing to lack of a power spray it is therefore impossible to say if one or more yearly sprayings would check the disease and if they

THE UNIVERSITY OF CHICAGO
LIBRARY

2

1

1

1

they

would prove economically sound.

In Pemba considerable improvement has been effected by cutting out all ~~d~~ⁿying leaves and twigs and ~~b~~ⁿuring them before the spores are scattered. At the same time new healthy growth has been ~~en~~couraged by better cultivation.

It should be noted, that the presence of red spots on the leaves is not necessarily an indication that the die back fungus is present. Attacked leaves often, but not always, turn red at the point of entry of the fungus and many red spots are quite free from the fungus. Experiment has shown that a mechanical injury will sometimes, but not always, result in the production of a red spot and it is suggested that the redness accompanies any injury to oil containing cells; it is not necessarily an indication of disease.

In this connection it may^{be} of interest to note that the spotted leaves brought, by Mr. C.O'Connor from Madagascar, in 1922, contained a fungus, only near the point of injury. It is probable that this fungus is saprophytic and may only have invaded the leaf after it was picked. There was no indication of the presence of fungal hyphae riddling the tissues, such as one finds in leaves with "die back" in Zanzibar.

In addition to the two important diseases already described the clove tree in this country suffers from several other pests, which however, will only be shortly referred to here.

2. Ants. Several species of ants are very common, especially in badly cultivated shambas and in some cases they cause considerable loss. The damage done by them was recognised in 1892 and is mentioned in Mr. Fitzgeralds report (9)

In the clove nurseries the white ant does much damage

damage

eating through hundreds of young seedlings just below the "collar". I hope in 1923 to carry out some trials as to the best way of dealing with this pest in the nursery beds.

As has already been stated the ant helps to spread root rot by carrying the spores to fresh ground.

In unhoed ground ants are very numerous and often do much damage by eating off the young roots of the clove, thus cutting off the water supply and preparing the way for the entry of fungi. One ant, known to the natives as Chungu-uvundo, seems to be particularly harmful and can easily be detected by its peculiar smell of decayed meat. It is probable also, that the ants poison the ground, thus checking root growth.

The Maji-yamoto ant; is common in badly cultivated shambas, it is seldom found if the grass is not allowed to grow. This ant binds the leaves together and in many cases, owing to its habit of attacking the clove pickers, causes a loss of the entire crop of a tree. In many shambas it is the custom to get rid of the ants by means of smoke, unfortunately this often results in the burning of the tree. A better remedy is to keep the ground clean and so avoid the presence of these Beetles. tiresome pests. The grub of a beetle is sometimes responsible for the death of young plants which are attacked at the collar or just below it. Several losses occurred on the Farseilles shamba in 1922. D^r Aders tells me that the beetle probably belongs to the section *Betonidae*.

Kirukia. The Loranthus, a member of the mistletoe family and better known as Kirukia, in spite of legislation still does damage in Zanzibar; fortunately this parasite is not found in Pemba. It should always be cut off and burnt as soon as found and on no account should it be allowed to produce seeds.

Cassytha.

The Cassytha filiformis, or "Mlangamia" of the natives is ^S another parasite common in neglected shambas of both islands, it is very harmful in young ~~young~~ plantations where it often smothers the trees. It should be pulled up and burnt.

Sooty Mould.

Occasionally a clove tree may be found with all its leaves thickly covered with a soot like growth. Several fungi^s may cause this appearance, they are none of them parasites but merely saprophytes feeding on the sugary honey dew deposited by insects. The hot sun dries up the secretion which then peels off taking the fungus with it. Though disfiguring, it is only harmful, because it chokes the leaf for a short time. Cases were seen at Dunga, Selem and several other Pemba shambas.



Summary of clove diseases and pests dealt with.

1. Root rot. with ^Psymptoms known as "sudden death" and "die back" is caused by a fungus Peziza caryophyllata *(translational name)*
 Treatment. Destruction of diseased trees.
 Isolation of infected areas by means of trenches.
 Better cultivation to induce fresh root formation.
2. Die Back. caused by a fungus Diplodia eugenioides *(translational name)*
 in conjunction with an alga, Cephaleuros ^{mycoidea} ~~virescens~~
 Treatment. Burn infected leaves and branches.
^{Wind}
~~Wind~~ breaks.
 Better cultivation.
 Spraying.
3. Debility. due to bad soil conditions and old age.
 Treatment. Better cultivation.
 Application of lime.
 Pruning weak growths.
4. Beetles. attack young trees in the plantation, they must be ^{and} watched for ~~a~~ destroyed.
5. Ants. attack seedlings as well as old trees.
 Discourage the ants by clean cultivation.
6. Loranthus. is found in Zanzibar and must be destroyed.
7. Cassytha. is found in Zanzibar and Pemba, it damages young trees and must be torn up and burnt.
8. Sooty Mould. though disfiguring is ~~isx~~ not very harmful.

II REPORT ON VARIOUS DISEASES.

1. Cocconut diseases.

Cocconuts in both Zanzibar and Pemba have a ^{bad} ~~bred~~ rot disease. A few plants from both islands have been examined and yielded a variety of fungi and bacteria. This disease has been reported from many countries and the reports on it are most conflicting, some workers attribute it to a special variety of Bacillus coli, ^{- Bacillus coli,} others believe it to be caused by Phytophthora palmivora. The question, as to what the ^s disease in this country is caused by, is a difficult one and has had to be put on one side owing to the clove investigation; this is a pity as the disease is spreading and should be investigated before it becomes more firmly established. Observation shows that it is infectious.

2. Cassava, or Mhogo, is very largely planted by the natives for their own consumption. Owing to the large amount of disease which is prevalent, a poor yield is obtained. The disease appears to be the same as that known as ~~"the"~~ curl disease which I found to be very common in Tanga. The disease first appears as pale yellow areas between the veins of young leaves, the chlorosis spreads, the leaf grows irregularly and the stem remains stunted. The half starved shoots are unable to form good tuberous roots and the crop is usually valueless.

The disease has been attributed to various causes, the chief of which are briefly mentioned. Dammer (7) attributes it to bad cultivation; Sadebeck (20) considers the disease is due to a fungus; Warburg (21) believes that insects are responsible; Zimmerman (25) disposes of these theories and believes that the disease is a true ~~to~~ mosaic disease akin to the infectious mosaic diseases of Tobacco and Malvaceae.

A similar disease has been reported from Florida and Floyd (10) considers it to be of physiological ^{origin} due to unfavourable soil conditions.

~~XXXXXXXXXX~~

10. The tenth part of the document is a list of names.

11. The eleventh part of the document is a list of names.

12. The twelfth part of the document is a list of names.

13. The thirteenth part of the document is a list of names.

14. The fourteenth part of the document is a list of names.

15. The fifteenth part of the document is a list of names.

16. The sixteenth part of the document is a list of names.

17. The seventeenth part of the document is a list of names.

18. The eighteenth part of the document is a list of names.

19. The nineteenth part of the document is a list of names.

20. The twentieth part of the document is a list of names.

21. The twenty-first part of the document is a list of names.

22. The twenty-second part of the document is a list of names.

23. The twenty-third part of the document is a list of names.

24. The twenty-fourth part of the document is a list of names.

A preliminary investigation which has had to be temporarily abandoned owing to clove work, has revealed the following facts.

1. Plants free from disease can be raised from seed.
2. Stock grown from seed yielded a poor crop but cuttings grown from the mature "seedling stock" have given excellent crops.
3. Disease free stock when raised in this way has remained immune when planted close to diseased plants.
4. Cuttings taken from diseased stock were found to be infected with a fungus.
5. Cuttings of immune stock did not show any fungus though growing in the same bed with the diseased specimens.
6. Aphis is often present on diseased and healthy stock it has not been found to transmit the disease.
7. Diseased and healthy plants often develop side by side, the disease is therefore not due to soil conditions.

It is suggested by these preliminary observations that the disease in this country is due to a fungus which is present in the tissues of the stem and that great care should be exercised in choosing stem cuttings for seed purposes. No cutting should be made, even from the healthy stems, of plants which show the slightest trace of disease in any of its branches.

A leaf spot disease is found on the Cassava, it does not occur, as far as I have seen it, in sufficient quantity to damage the crop and has therefore not been examined in detail. It is due to a fungus Cercospora Henningsii Allesch which has also been reported from East Africa, Ceylon and Java. In the West Indies, this or a nearly allied fungus causes considerable loss but can be easily controlled by spraying. It is described by Butler (5)

3. ^{j u}Cajanus indicus, the pigeon pea is grown in the vicinity of towns and is very subject to disease. Often before the crop is ripe the leaves turn yellow and wilt rapidly causing the entire loss of the crop.

Several diseased plants were examined as the presence of a Fusarium was suspected.

- #1 Fusarium udum is the cause of a serious wilt disease of Cajanus in India, fortunately it has not yet been found in our diseased plants.

The disease was found to be due to an insect which pierces the stem and lays its eggs under the bark. The grubs when they hatch out, first cause slight hypertrophy of the stem, soon wilting occurs and the shoot dies, very frequently breaking off at the point of infection.

Mr. O'Connor has suggested that the insect responsible for the damage is probably a night flying moth.

4. Cucumber is very liable to the common mildew Erysiphe Cichoracearum which is found all over the World.

It is readily controlled with either Bordeaux or Vermorels spray; several treatments are necessary as owing to the heavy ^{dew} ~~due~~ prevalent in these islands fresh infections are constantly occurring.

III. REPORT ON EXPERIMENTAL ~~AND~~ GARDEN.

Experiment Garden at Weti.

A small experiment garden was started in Weti in 1921.

Experiments in connection with clove and cassava have been carried ^{on} and are recorded elsewhere.

An attempt has been made to collect examples of the different varieties of native crops and to test their value; the results so far obtained are briefly described.

The following crops were selected for examination.

1. Cassava or Mohogo.
2. Ipomea, the sweet potato or kiazi.
3. The Yam, kiazi kubwa.
4. The Banana.
5. Pigeon Pea, Cajanus indicus.
6. Ricinus communis.
7. Indian corn, Zea mais.



Cassava. The following distinct varieties are recognised by the natives in Pemba. The figure given for the crop is only a comparative one as the plants were grown on partially exhausted soil and the crop was below the average

1. Binti Athmani. A quick grower and very good bearer. The chief favourite owing to its yield and the fact that it does not become woody if left too long in the ground. Yield 4 lbs per root. Disease free stock has been raised of this variety.
2. Usiniombe. The best cropper but very liable to become woody if it is not lifted directly the roots are ripe. Yield 5 lbs per root. Disease free stock has been raised of this variety.
3. Mzungu Mpemba. A weak grower and poor cropper. Yield $2\frac{1}{2}$ lbs per root. Disease free stock has been raised of this variety.
4. Sena. Said to be the worst cropper and very seldom grown. Yield only $1\frac{1}{2}$ lbs per root. Disease free stock has been raised of this variety.

The above four varieties have been grown from cuttings taken from healthy plants raised from seed. The resulting stock is free from disease and so far has shown itself to be immune.

The following varieties were grown from cuttings of diseased plants as no seed was obtainable. The weights given are from specimens which showed only slight traces of the disease.

5. Mkomoka Mbio. yield 3 lbs per root
6. Binti Ali. yield 3 lbs per root
7. Kitua. yield $2\frac{3}{4}$ lbs per root
8. Mkasama. yield $2\frac{1}{4}$ lbs per root
9. Sogea. yield $2\frac{1}{2}$ lbs per root
10. Kajeyeve. yield $1\frac{3}{4}$ lbs per root

Owing to the fact that I have only been able to

to

raise healthy characteristic stock of four out of the ten varieties I have not attempted to write a description of the varietal characters but they are quite distinct and easily recognised by many of the natives.

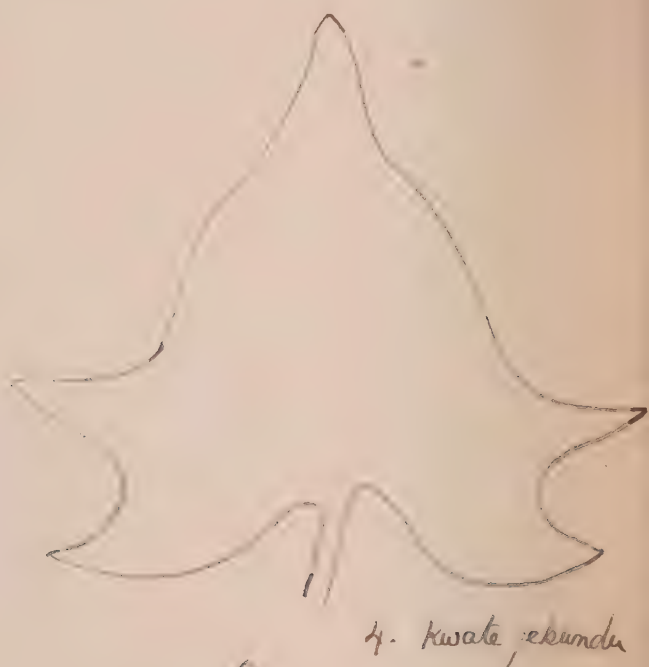
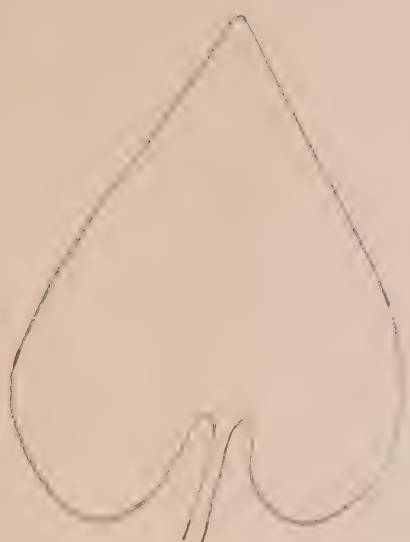
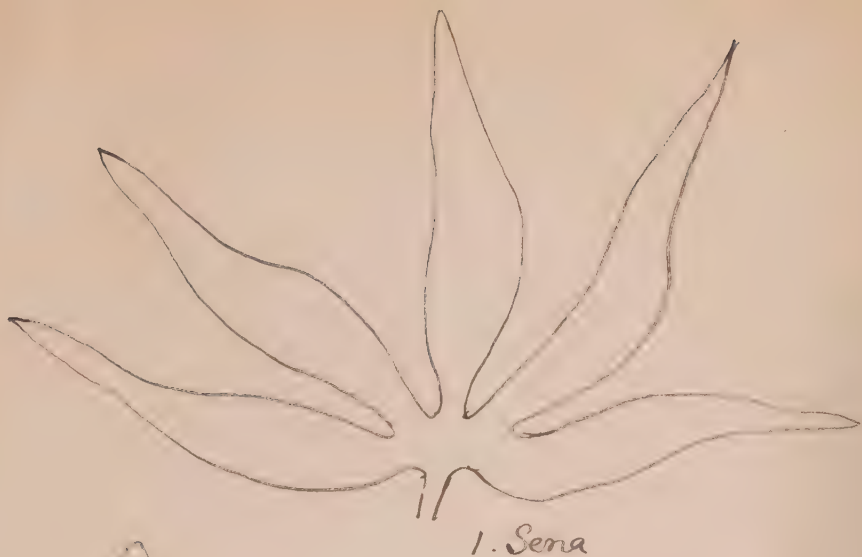


Figure 8. Sweet Potato
To show shape of leaf in the different varieties

2. Ipomaea Batatas, the sweet potato is grown extensively in both Pemba and Zanzibar. Many natives ~~y~~asked will say there are two varieties only, the white and the red. I have however been able to collect five distinct varieties, known to the native experts under the following names.

Section A. Skin white.

1. Sena. Also known as Kindoro and Kibangi in different parts of Zanzibar. Large crop. Good flavour. Skin white, flesh white. Leaf ~~&~~ 5-palmatisect. Segments acute. (fig. 8,1)
2. Kwate Jeupe. Very small crop. Poor flavour. Skin white. Flesh white. Leaf cordate and entire (see fig. 8,2.)

Section B. Skin Red.

3. Kirihani. Very good crop and good flavour. It ripens more quickly than any other variety. Skin red, flesh white. Leaf trifid but 7 toothed. Pale purple veins (see fig. 8,3.)
4. Kwate Jekundu. Very small crop. Poor flavour. Skin red, flesh white. Leaf 5-fid. (fig. 8,4.)

Section C. Skin yellow.

5. Halintumwa. Fairly good ~~a~~^c crop but roots are much shorter than those of Kirihani. Flavour good. Skin yellow, flesh yellow. Leaf cordate and 3 toothed. (fig. 8,5.)

10310
10311
10312
10313
10314

10315
10316
10317
10318
10319

10320
10321
10322
10323
10324

10325
10326
10327
10328
10329

10330
10331
10332
10333
10334

10335
10336
10337
10338
10339
10340

3. The Yam is not very much grown in Pemba it is found at Fundo and occasionally also roots are grown in a few villages on the main island. In some parts of Zanzibar such as the Chwaka district, it is the staple food of ~~the~~ Wahadimu, in other parts of the island it is only grown occasionally.

I have only been able so far to collect four varieties which are now established in the garden at Weti.

1. Mviringo. with a large ^{turnip}~~triangular~~ shaped root.
A large cropper of good flavour. Collected from Fundo.
 2. Kinana. Roots same shape as Mviringo but very much smaller. Crop small. Flavour good.
Collected from Dunga.
 3. Madole. bears a large number of finger like roots.
Crop very large. Flavour fine, Collected from Fundo.
 4. Mwendachi. The roots are very like Madole but grow much deeper down; it is a good variety for light dry soils. Crop good. Flavour good.
Collected from Dunga.
4. The Banana, Musa Sapientum is grown in both Zanzibar and Pemba. The following distinct native varieties have been planted in the garden, some of them have not yet fruited and the following description will probably require much revision.

1. Paka. Plant of Medium size.
Stem blue green.
Ripe fruit green
Spathe at end of peduncle white.
2. Mjenga Tongo.
Plant very tall.
Leaf sheath with large black blotches.
Ripe fruit green and of good flavour. ~~Large~~

Fruit very apt to split as it ripens, *but*
this may have been due to bad conditions.

3. MZUNGU MWEUPE.

Plant very tall.

Stem^m green with a good deal of red.

Fruit very pale yellow, almost white when
ripe.

4. Mzungu Mwekundu.

Plant very tall.

Stem very red.

Fruit large, red and of good flavour.

5. Mfichachana.

Plant very tall.

Stem green.

Fruit partly hidden in leaves, long and
very like those of Malimaaua, Fruit yellow.

6. Mikonde.

Plant of medium height.

Stem with much black and purple.

Leaf edges black.

Fruit outside the leaves, small, short
and thick.

7. Kisukari. (Sugar banana)

Plant small but not as short as Kigur^we.

Stem green with a little black.

Leaf sheath edges very red.

Petioles short.

Fruit short and slender. Very sweet.

8. Mkono Watenbo.

Plant very tall.

Reddish streaks on stem.

Fruit the largest of all and curved like
an elephant's trunk, Bears two to four
bunches only.

Good for cooking when ripe, not for
desert.

9. Muzu.

Very tall like Mkono Watembo.

Stem green without ^{tr}speaks.

Fruit angular, rather small and set well apart.

Bunches numerous,

10. Mchinjadamu.

Stem very tall and red.

Edges of petioles red.

Fruit not yet seen.

11. Mlalimaua.

plant

Rather shorter/^{plant}than the last three,
very like Bokoboko.

Stem with much black.

Fruit not yet seen.

12. Bpkoboko.

Stem very pale green and less black
than Mlalimaua.

Fruit very thick. Length 5 to 6 inches
and circumference 7 to 8 inches.

13. Kipukusa.

Very like Bokoboko but rather taller.

Fruit length 5 to 6 inches and circum-
ference about 5 inches.

14. Msunuha. synonym. Mlalmakumbi.

Plant very like Kisukari.

Fruit very thick and short.

15. Kigurwe.

Plants very short.

Stems green.

Fruit very short and thick.

16. Kichaazi.

Plant almost as short as Kigurwe.

ant tall.

. Ripe fruit green. (a) flowering bract white.

(b) " " red.

. Ripe fruit pale yellow to white.

. Ripe fruit red.

. Ripe fruit yellow.

1. Fruit partly hidden ^{by} leaves.

2. Fruit outside leaves.

(a) fruit small.

I. Short and thick.

II. rather longer and slender.

(b) fruit large (in order of length)

1. Paka.

2. Mjanga Mingo.

3. Mzungu Mucupe.

4. Mzungu Mchundu.

5. Mfichachana.

6. Kikonde.

7. Kisukari.

8. Mkono Watembo.

9. Mzuzu.

10. Mchinjadamu.

11. Mlaimaua.

12. Tokoboko.

13. Kipukusa.

14. Msunuha.

15. Kigurwe.

16. Kichaazi.

ant ~~away~~ dwarf

5. Cajanus indicus. I have only found two varieties of Pigeon pea. Neither of which have any native name as far as I can find out. Both are equally liable to the attacks of insects.

1. Large leaved variety.
2. Small leaved variety.

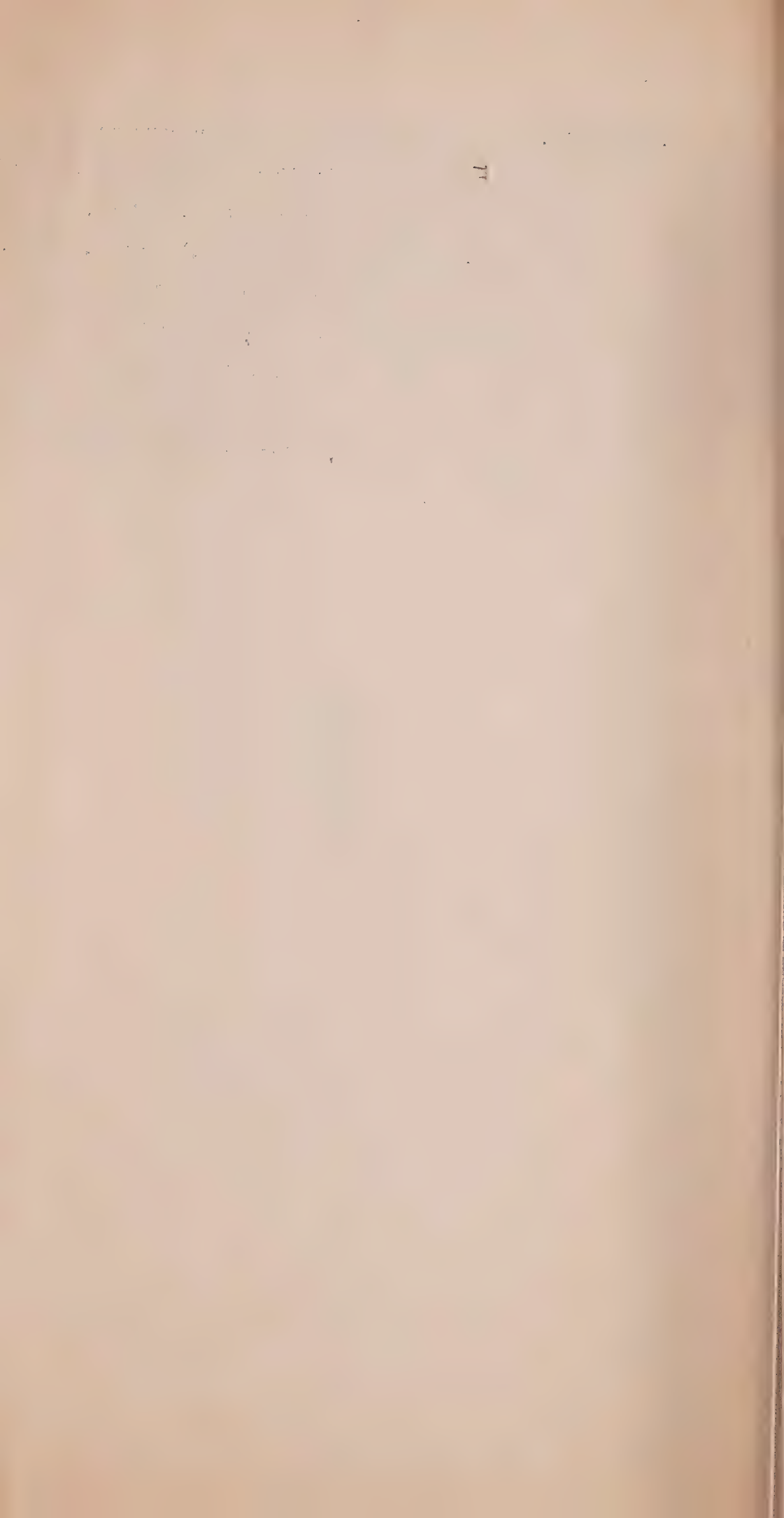
6. Ricinus communis. Seeds of Ricinus zanzibarensis^{SIS}, a pink ^d stemmed variety, were sent to me for trial. They germinated well but produced ¹ plants in no way different from the typical Ricinus communis. The individual variations in stem colour etc were not sufficient to constitute any varietal difference.



7. Zea Mais.

The variety of Indian corn occasionally grown in Fundo and Pemba is a very poor one. A cob of "Ivory King" was given to me by Mr. Sheldon, it had been sent by Mr. Anderson (late I of P.) from S. Africa.

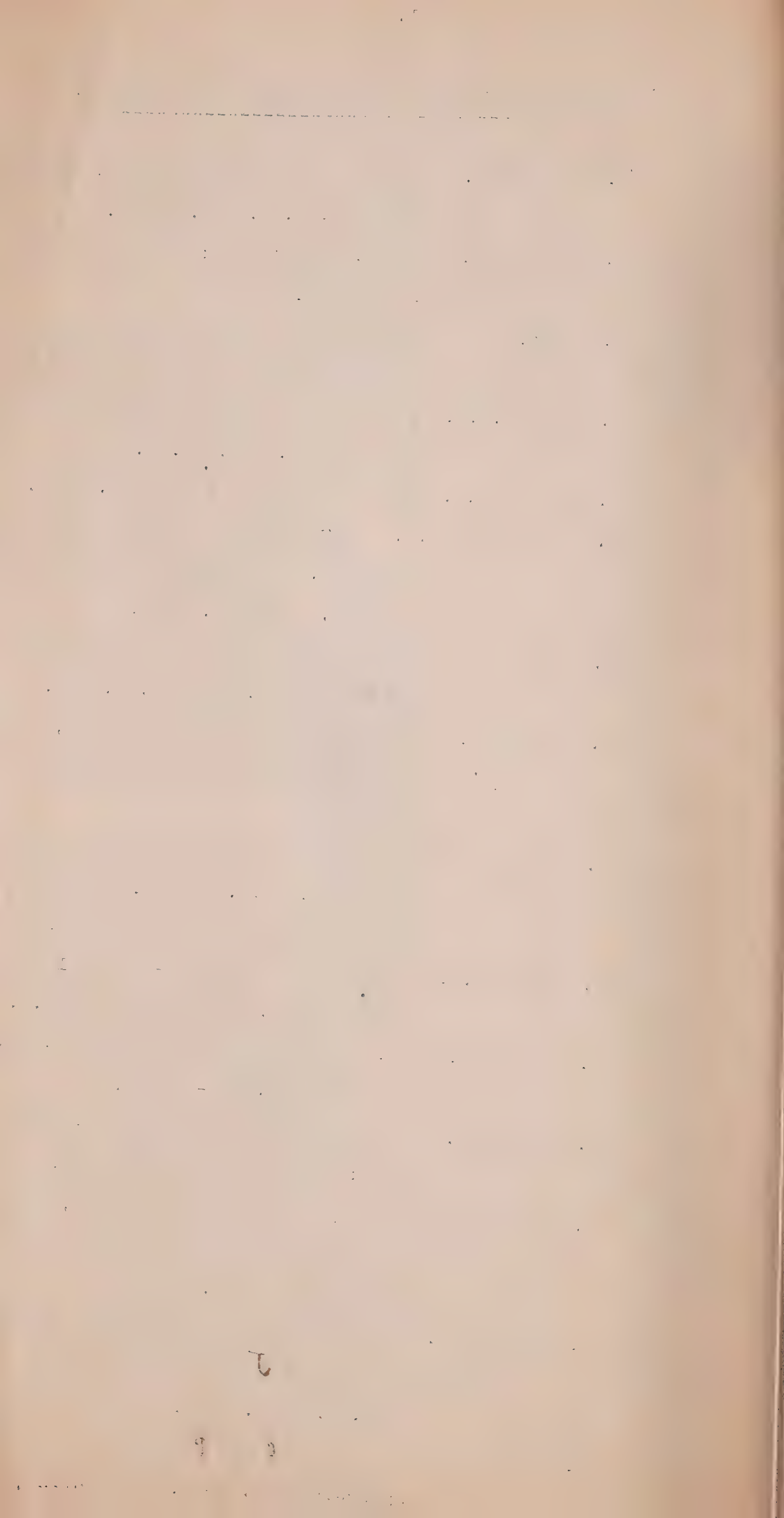
Owing to lack of seed the plants were not grown in sufficient numbers to insure^T natural pollination and consequently those on the outside of the bed did not bear. The pods which set, were large and bore large white^u mealy seeds of good flavour. They were much better than the ^{local} small variety.



PART IV. BIBLIOGRAPHY.

List of Papers and Books referred to in Report.

1. Anonymous. Work of the Inspection Staff, Malayan Agric: Journal X. 4. p. III. III, 1922.
2. Anonymous. Cloves. Agric: Bull: Malay Peninsula Ap. 1897 p. 113--115.
3. Buée. Narrative of the Successful Manner of Cultivating the Clove Tree in Dominica. 1797.
4. Butler. E.J. Wilt disease of Pignon Pea and Pepper - Mem: Agric: India. Bot. II. 9.
5. Butler E.J. Fungi and disease in plants. 1918.
6. Cunningham D.D. Bark Blight caused by Cephaleuros. Virescens. Sq. Memor~~ias~~as of Medical Officers in India. Part 10. 1897.
7. Dammer. Engler's Pflanzenwelt Ostafrikas und der Nachbargebiete. Teil B. p. 143.
8. Dowson W. Report on Cloves dated 22/6/19, Unpublished, from Files of Zanzibar Government No. D. 67.2 of 192 .
9. Fitzgerald. Spice and other cultivations of Zanzibar and Pemba. F.O. Papers. Abstract published in Kew Bulletin 293 for 1893 p. 17.
10. Floyd B.F. Chlorosis of Cassava - Annual report of Florida Agric: Expt. Station 1969. p. 76.
11. Gorkom K.W. Van. Ost Indische Cultures Vol. III. part 39 p 372. No. 480 - 1917.
12. Humphrey. Powdery Mildew of Cucumber - Report. Mass: Expt. Station, IX and X.
13. Imperial Institute of the United Kingdom, the Colonies and India, unpublished report in Zanzibar Government files.
14. Kersten G. Untersuchungen über der Familie der ~~Chroolepide~~ⁿ Annales du ~~J~~ Jardin de Buit~~enzorg~~^{enzorg} Vol. X. p 24. 1881.
15. Key. Story of a Clove Plantation - Tropical Agriculturist. 1900. and quoted in Pic



Ridley's

Spices p 181.

16. Moller A.F. Der Tropen pflanz^{er} 1902 Vol. VI p 255.
- 16.a. Mann & Hutchinson. *Cephaelis virens*; Red Rush of Tea: Mem. Ag. Ind Bot. I. 6.
17. O'Connor C. Unpublished report on visit to Madagascar.
1922, Zanzibar Government files.
18. Pearce F. B. Zanzibar. 1920.
19. Ridley H.N. Spices, 1912 Macmillan & Co. p 155 to 196.
20. Sadebeck. Kulturgewächse der deutschen Kolonien und ^{ih} ~~Vire~~ Erzeugnisse. 1899 p. 77.
21. Warburg O. Mitteilungen ~~Vor~~ Forschungsreis ^u Gel. a. d. Deutsch Schutzgebieten 1894. Bd. VII. p. 132.
22. Warburg O. Der Tropenpflanzen. 1898 Vol. II p 356-358.
23. Watt G. Commercial Products of India. p. 526.
24. Welsford E. J. Studies in the Physiology of Parasitism. Part II. Infection by Botrytis cinerea. Annals of Bot. XXX p 389. 1916.
25. Zimmermann. Die Krauselkrankheit des Maniok (Mhogo) ^P ~~Der~~ Pflanzen II p 145 to 153. 1906.
" " V. p 182 -- 183. 1909.
26. Zimmermann. Untersuchungen ueber ^{Ex} ~~Exopische~~ Pflanzenkrankheiten; Ber. hand. U. Forst^W. Deut. Ostafrika. II.

Appendix.

The ⁰ ~~curse~~_^ of the work in the clove diseases, has led to a close examination of all parts of the plant.

I have been struck with ^{the} large amount of some oily deposit, presumably ^e Eugenol or some derivative of it, which occurs in the twigs and stems, even being present in the trunks of trees which have been cut down for sudden death.

At present, owing to the difficulty and expense of transport it is not possible to sell all trees cut down for sudden death. It is possible that ^{these} ~~these~~ ^{if distilled} trunks might yield a considerable amount of clove oil ~~if they were distilled~~. In Madagascar (17) it pays to distill oil from the twigs and branches broken in picking, it might pay to do the same with our broken branches and cut down trees.

I have tried to fix up a still to ~~test~~^{test} this but have had to give it up temporarily, as the Water Supply at Weti is at present very limited.

